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Film Monitoring in Peacetime Applications of Atomic Energy

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This is said to be the atomic age. What does that mean to you? Do you associate with this phrase only mass destruction by atomic weapons, or are you, like many others, beginning to realize that atomic energy is now being used in its peace-time application to aid mankind and to further his knowledge? Great developments in this field have taken place since the military use of the atom bomb over Japan.

Radioactivity

Atomic reactors in Canada, the United States, the United Kingdom and other countries are now producing large quantities of radioactive isotopes—elements like ordinary carbon, iodine, phosphorus, cobalt, iridium, etc., which have been made radioactive by treatment in an atomic furnace or reactor. These "radioisotopes" as they are called are now used in many phases of every day life, in medicine, industry and fundamental research.

Radioactive atoms look and act chemically just like their non-radioactive counterparts, but an unstable condition in the nucleus or core has been created by bombardment with neutrons in the atomic reactor and, in an effort to regain stability, the atom emits alpha or beta particles or gamma rays. Of these, the gamma ray is the most penetrating but it can be stopped or absorbed more easily by heavier materials than by light ones. The alpha particle has the greatest ionizing ability and it is felt that this process of ionization is responsible for many of the harmful effects of radiation on man. There are two classes of radiation hazards, external and internal. The gamma ray is the most hazardous in the external class because of tts penetrating power while the alpha particle is the most dangerous internally because of its high ionizing ability.

COVER PHOTO: This shows the measuring instrument used in determining the degree of blackening of special photographic films worn by workers in the fields of x-ray and radioactivity. From these measurements it is possible to interpret the weekly exposure to harmful radiation. See article on "Film Monitoring in Peacetime Applications of Atomic Energy".

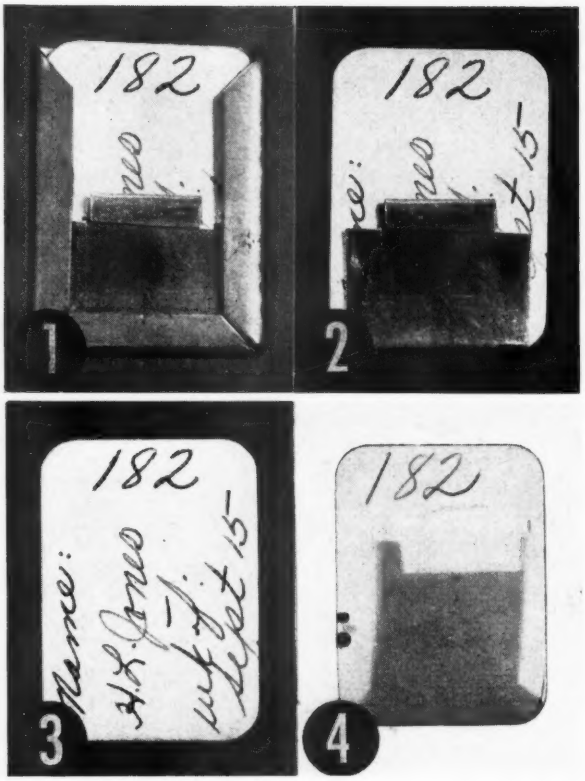
The Need for Detection Instruments

As these radiations can cause damage to living tissue and since the number of people associated with work involving radioactivity is increasing, a means of measuring exposures to ionizing radiation becomes more necessary. We must remember that we are unable to see, taste or smell radioactivity and therefore we must rely on some characteristic of radioactivity for its detection. The possible health hazards connected with this field were recognized in the early stages of the atomic energy projects and instruments capable of giving accurate and reliable interpretations of radiation exposures have been developed. The International Commission on Radiological Protection has established a weekly permissible exposure of 300 milliroentgens to x or gamma radiation. The milliroentgen is a unit of ionization which is related to the biological effects of ionizing radiation.

One of the earlier devices for the detection of radiation was the photographic film. With their small penetrating power alpha and beta particles are not readily detected by photographic films, but x and gamma rays, with their larger penetrating power, can be easily detected and measured by a photographic method.

Problems Connected with a Film Monitoring Service

X-ray films are suitable for detecting the presence of x or gamma radiation by showing a general blackening or density following such an exposure. A very sensitive or "fast" x-ray film is capable of detecting smaller amounts of radiation than an insensitive or "slow" film. For measurement of radiation exposures it is necessary to find a relationship between the density or film blackening and the exposure. This gives a



A typical monitoring film.

(1) The film as it appears with cadmium shield in the stainless steel film holder.
(2) The film with the cadmium shield alone.
(3) The film in its dental packet and without cadmium shield. This shows the film number, the name of the wearer and the week of use.
(4) The processed film showing the shielded area (at the top, in this case) and the unshielded as well as the identifying number.

measure of the ionization and therefore an indication of the safety of the working conditions. "Calibration" films are exposed to known amounts of radiation from a standard radium gamma ray source and a graph of resultant density versus exposure is drawn. The exposures can be calculated in milliroentgens when the source size, time of exposure and distances from source to films are known. The unknown exposures are then determined by comparison with this graph.

Studies have shown that the resultant film densities depend on other factors besides the radiation exposure. The developer temperature, developer activity, method of agitation, temperature and humidity effects all combine to produce unusual and variable results on the films. It has also become evident that the film response varies with changes in wave length of the radiation, that is, an exposure of 100 mr. (milliroentgens) to radiation from a diagnostic x-ray machine results in a different density from that of 100 mr. to radiation from a standard radium source. This is known as the wave length dependency effect and special precautions are needed if a film is to be used for measuring exposures in the low energy range. However, for exposures to x or gamma radiation of energy greater than 300 kilovolts the film response is uniform enough so that the wave length dependency factor does not need to be considered.

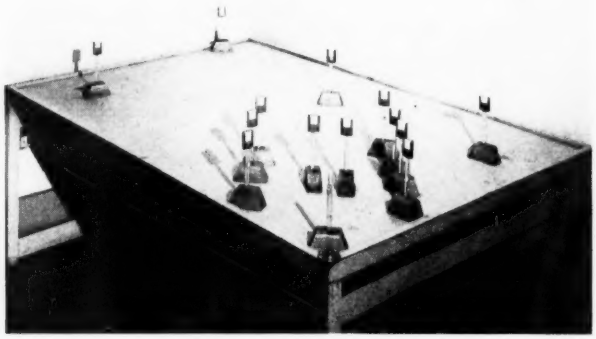
A Canadian Film Monitoring Service

In 1950 the Health Radiation Section was established under the Industrial Health Division of the Department of National Health and Welfare. One of the responsibilities of this Section was to set up and operate a film monitoring service for all users of radioactive isotopes in this country. In July 1951 the film service began operation and now serves groups in industry, medicine and fundamental research from coast to coast. Attempts have been made and are being made continually to minimize the variables present in any photographic monitoring system.

A weekly routine for the handling of the films has been adopted. The films are a special type of emulsion packaged in the conventional dental packet. Identification of the films in the laboratory at Ottawa depends on the date of the week of use and the number arbitrarily assigned to each film before it leaves Ottawa. A "control" film is sent along with each group to detect stray effects during transit and another "control" film for each group never leaves the laboratory in Ottawa. To reduce temperature and humidity effects during transit, each group is sealed in a moisture-proof envelope.

Films are worn for a one week period and a cadmium shield is placed over one end of each film to permit the detection and interpretation of exposures to low energy radiation.

"Calibration" films are processed at the same time as the unknowns. The processing unit handles 490 films at one time and must be completely filled to avoid wave pattern effects as a result of the mechanical agitation throughout all stages of the processing. The



The calibration table showing the radium needle hanging from the wire support on the lucite rod and the thirteen films located at fixed distances and each in an unobstructed path from the radium source. Exposures are calculated knowing the distances, the source strength and the length of time of the exposure.

dark room is itself temperature and humidity controlled and the processing solutions are independently temperature controlled in a water bath. The developer used gives a low chemical fog and requires a long development time.

Density measurements are made with a photoelectric transmission densitometer and "calibration" curves are drawn showing the measured densities under the shielded and unshielded portions of the calibration films against the calculated exposures. The unknown exposures are interpreted by comparison with these "calibration" curves. Reports are issued weekly to each group indicating exposures above 100 mr. and below 1500 mr.

Methods are continually being developed to improve the present system. Projects which are receiving particular attention at this time are a method of film identification, a conveyor system for handling the processing rack and a replenisher system to maintain the developer at a constant activity.

Also, construction is proceeding on an x-ray laboratory which will be used in connection with a program to develop a special film suitable for use in monitoring personnel working with low energy x or gamma radiation. Although the present service is limited in its accuracy to measuring exposure to radiation of energy greater than 300 kv., a number of hospital radiology departments are using it until the "x-ray" film becomes available.

In summary then, there is a new public health problem associated with the peace-time applications of atomic energy. This problem is being actively pursued by the Department of National Health and Welfare and a film monitoring service is now in operation. In this service, care has been taken to control the variables which are always present in such a photographic system.

Manual Artificial Respiration - The Holger Nielsen Method

By Industrial Health Division
Department of National Health and Welfare

Metabolism, the process by which food materials are converted into body tissues, and by which energy is produced for body function, depends on an adequate supply of oxygen for efficient operation. The respiratory and circulatory systems supply the necessary oxygen and eliminate a waste product of metabolism, carbon dioxide.

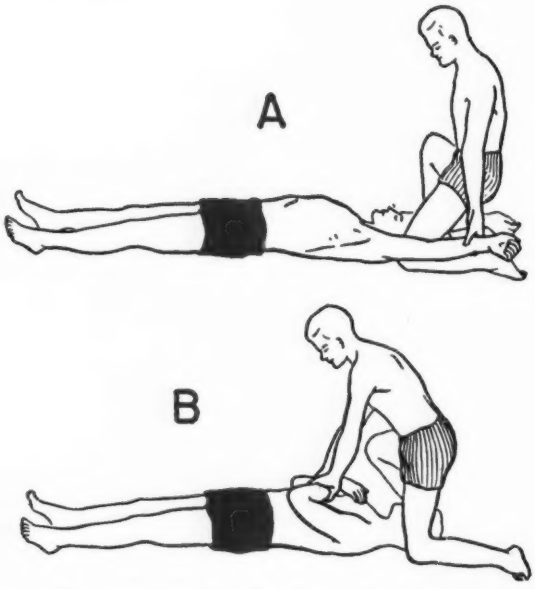
When, for any reason, breathing is stopped long enough to interfere with the process of metabolism the resulting condition is called asphyxia, and unless breathing is quickly restored the organism will die from lack of oxygen because the body cells have no means of storing this precious gas.

Among the many causes of asphyxia are gas inhalation, drowning, electric shock, suffocation, strangulation, overdose of drugs, injury to breathing mechanisms, freezing, hanging, oxygen deficient atmosphere, and inhalation of solvent vapours.

Emergency treatment of asphyxia involves the restoration of breathing by artifical means and this is referred to as "Artificial Respiration". Such treatment is by no means new, in fact it was practised long before the birth of Christ. In those times, one method consisted of placing the asphyxiated victim on his back and throwing hot pitch on his chest and abdomen, assuming that the shock would cause an involuntary gasp which would initiate breathing again. According to the Bible, Elijah, on discovering a boy who had stopped breathing, promptly laid his weight on the boy and removed it and repeated this operation until breathing was restored. Mouth to mouth breathing as a means of artificial respiration was described in the New Testament and even today physicians may use it to resuscitate the newborn. In the early centuries, two somewhat similar methods were employed. One of these consisted of placing the victim over a bent sapling and moving the sapling up and down rhythmically to instigate breathing; in the other method, the victim was lashed face downwards across a horse's back, and the horse was set off at a trot to jog the air in and out of the victim's lungs. In the sixteenth century, a bellows was first used to force air into the lungs and suck it out again, this method was the first attempt at mechanical artificial respiration and was the forerunner of the pulmotor, used for a short time in the late nineteenth and early twentieth centuries.

In France, in the eighteenth century, the method of rolling a drowning person over a barrel was practiced. This procedure was thought to drain water from the lungs, but it is now known that very little water gets into the lungs. However, the principle is similar to that of the Eve Rocking method.

In 1856, Dr. Marshall Hall introduced the principle of pressure on the walls of the thorax (1). His method consisted of alternately rolling the patient from a prone to a side position and back and then administering pressure on the back. This method was followed in 1857 by Silvester's arm-lift chest-pressure method (2)



Silvester method (arm lift-chest pressure) of manual artificial respiration. *A*, inspiration. *B*, expiration.

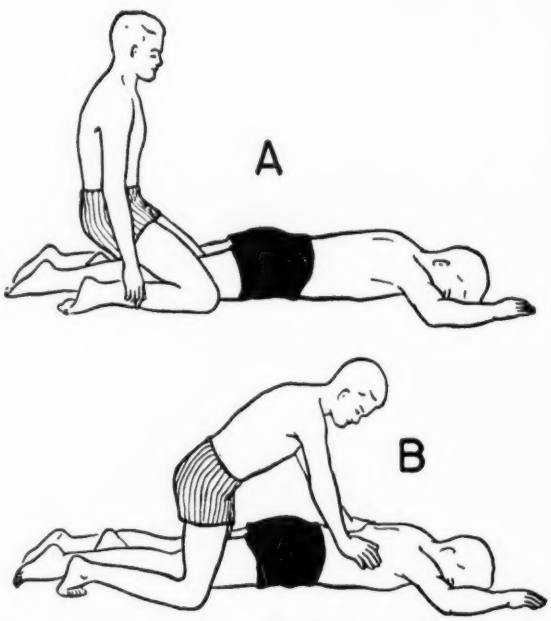
which consisted of placing the victim face upwards and alternately applying pressure to the front chest wall and stretching the arms above the head.

No method received very wide acceptance until 1903 when a new method was devised in England by Dr. Schafer (3), which, until recently, has superseded most others. The victim is placed face-down with the face turned to one side, and the cheek resting on one hand. The other arm is stretched forward to give greater chest capacity. The operator kneels beside or astraddle the victim's legs and with arms stiff rocks his body forward, thus applying pressure to the small of the back and lower ribs with the palms of the hands. Then the operator rocks back to a sitting position, thus releasing the pressure. This cycle is repeated 12 to 15 times per minute. This "push" method induces active expiration but inspiration is passive. Other methods are the Emerson or hip-lift (4), the Schafer-Emerson-Ivy or hip-lift back-pressure (5) and the hip-roll back-pressure (6), involving "pull' and "push-pull' principles. In the second of these, the operator kneels astride the victim, resting on one foot and one knee, and after applying pressure on the back, he creates an active inspiration by lifting and lowering the patient's hips 8 to 10 inches off the ground. The hip-roll is the same except that the active inspiration is created by rolling the subject sideways up on the operator's bent knee. The hip-lift method induces active inspiration only.

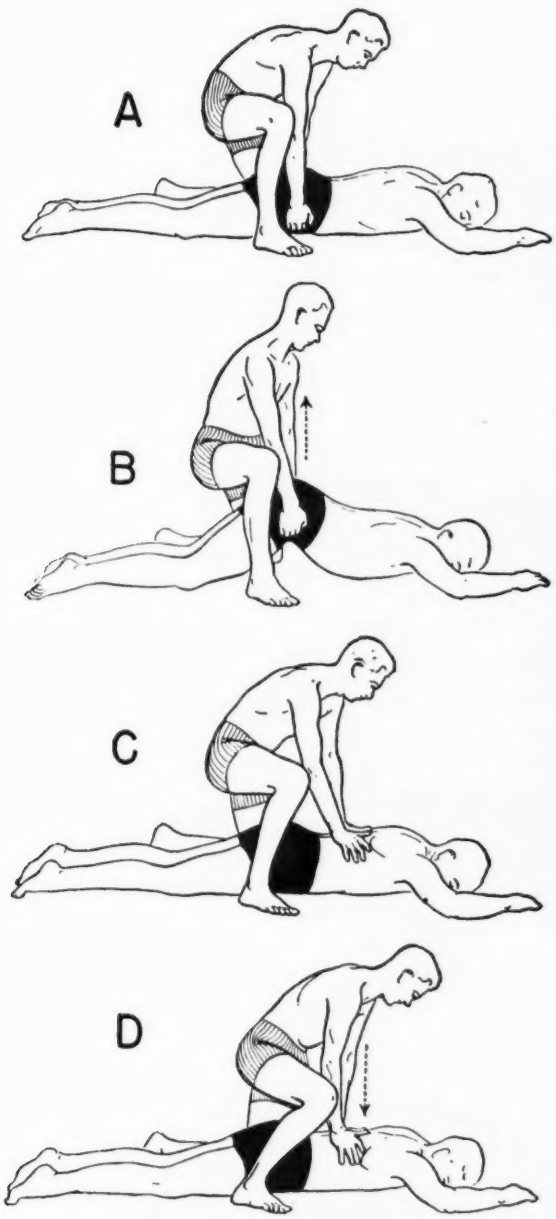
Asphyxia, due to electric shock sustained while climbing hydro poles, often proved fatal because of the delay in lowering the victim to the ground before administering artificial respiration. In 1931, E. W. Oesterreich of the Duquesne Light Co., Pittsburg, Pa., introduced the Pole Top method (7, 8) designed to resuscitate victims before lowering them to the ground, and this method has proved very successful. The rescuer ascends quickly to the victim, secures his own safety belt around the pole and places the victim astride it, facing the pole. Then, the victim's abdomen is alternately compressed inward and upward and released about 12 to 15 times a minute, thus producing a change of air in the lungs. This type of artificial respiration is continued until both victim and rescuer can be safely lowered to the ground, where one of the other recognized methods can be put into operation.

The Katsu method (9), uncertain of origin, but Japanese in name, is essentially similar to the Pole Top method except that the operator sits on the ground behind the victim, with the victim between his spread legs, and leaning against his chest. The operator places his hands on the victim's abdomen below the waist and rhythmically applies and releases pressure to the abdomen about 12 times per minute. Several modifications of this method were used in military investigations.

Although it is partly mechanical in nature, the Eve Rocking method, introduced in 1931 by F. C. Eve (10), deserves mention here, because it involves the same principle as push-pull methods. The victim is fastened securely, face-down, on a board or stretcher set on a fulcrum and teetered through a 90° arc at the rate of about 10 times per minute. In the head-down position, the viscera exert pressure on the diaphragm thus forcing air out of the lungs. As the feet-down position is assumed, the viscera drop back, releasing the pressure and permitting an inflow of air. This method, although very effective, introduces time loss in preparation, re-



Schafer prone pressure method of manual artificial respiration. *A*, inspiration. *B*, expiration.



Hip lift-back pressure method of manual artificial respiration. *A*, placing hands for hip lift. *B*, hip lift. *C*, placing hands for back pressure. *D*, back pressure.

quires special apparatus and should be preceded by one of the manual methods.

In 1931, Holger Nielsen, a Danish Lieutenant Colonel, devised the arm-lift back-pressure method of artificial respiration (11) which was introduced in Denmark in 1932 after it was tried out by the Nobel prize-winner, Professor August Krogh, Ph.D., and Professor I. Lindhard, M.D., and it has been extensively used there for cases of asphyxia ever since. This method was adopted by the American National Red Cross, the American Medical Association, the United States Department of Defence, the United States Public Health Service and the United States Bureau of Mines, on December 3, 1951, and recommended for adoption at the 18th International Red Cross Conference in July 1952.

The following resolution was adopted by the conference:

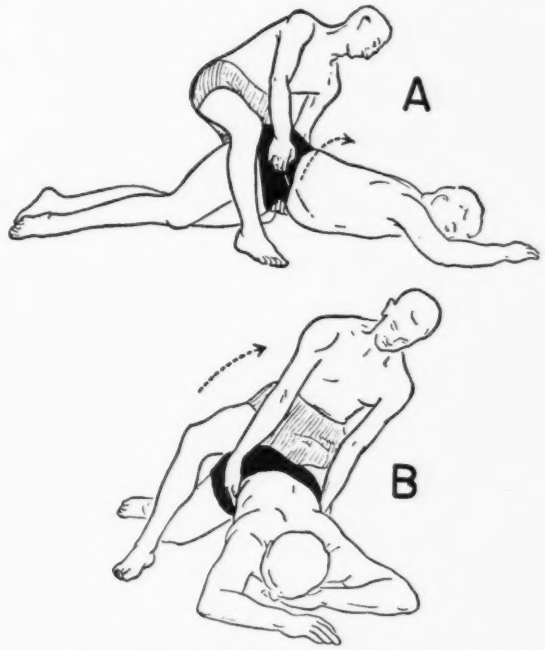
"The 18th International Red Cross Conference, recognizing the superiority of the Holger Nielsen method of manual artificial respiration over the majority of other similar methods, particularly in respect of pulmonary ventilation, ease of execution and simplicity of instruction,

recommends that the Holger Nielsen method of artificial respiration be adopted as soon as feasible for general basic instruction of Red Cross personnel; this should not exclude, however, the teaching of other methods of artificial respiration for use in special circumstances and conditions.

This Resolution was adopted."

The Holger Nielsen Standard Method

Preliminary preparation for the Holger Nielsen method is the same as for any other method. The victim is first removed quickly from the environment and laid on a fairly level surface. If the surface is slightly sloping, the head should be lower than the feet if his face is pale, and higher than his feet if it is flushed or bluish. Where feasible outer clothing is removed, but in any event the belt and collar are loosened to prevent restriction of circulation. In drowning cases, the mouth should be cleared of mud, seaweed or any other obstruction with the forefinger, preferably wrapped with a handkerchief. If he is lying on his back he



Hip roll-back pressure method of manual artificial respiration. *A*, side view of hip roll. *B*, front view of hip roll.

Pole Top Method of Artificial Respiration

should be turned over in the following manner: the operator kneels on his right knee in front of the patient's head, with his left foot flat on the ground out at the side. he pulls the victim's arms up above the latter's head, grips his upper left arm with both hands, and turns him over to the right with a steady pull; when the patient is half-over, the operator places his right hand under the patient's forehead to prevent his face from striking the ground, and completes the turn with his left hand. In the Holger Nielsen method, the patient's hands are then placed palm downward one over the other with his head resting on them so that mouth and nose are not obstructed. Then with the flat hand, the operator slaps him between the shoulder blades smartly. This shock should make the mouth fall open and the tongue fall forward. It should also discharge any water from upper breathing passages if the patient is a drowning victim. If the nose and mouth are not clear of the ground, the head should be raised with some sort of pad or turned sideways on the hands. Body warmth should be maintained by blankets or other available material placed both under and over the victim.

The operator now places one knee about 6 to 12 inches from the patient's head, the inner side of the knee on a line with the victim's cheek. He then places his other foot at the patient's elbow with the heel level with it, and toes pointing forward, or in the position he finds most comfortable through practice. Women should remove high heeled shoes before beginning. The rescuer places his hands on the victim's back, palms on the shoulder blades, thumbs on the backbone and fingers pointing towards the victim's feet. In a modification of this method, the hands are placed just below the scapulae (18). He rocks forward with arms held straight until they are vertical, meanwhile exerting a smooth gentle, evenly-increasing downward pressure on the patient's back. This movement should take two and one-half seconds and must be carried out while counting "one-two-three". Counting "four" he rocks back, releasing the pressure, and without bending his arms, grasps the patient's upper arms near the elbow and continuing his rocking backward, performs a steady forward and upward pulling movement which serves to relieve the patient's chest of the weight of his trunk. The trunk should not be raised clear of the ground and the position of the forehead on the hands should not be disturbed. This movement is carried out to the count of "Five-six-seven". On the count of "eight", the patient's shoulders are gently lowered and the operator moves his hands to the starting position in one second. This cycle should be completed about nine times per minute.

In applying pressure, be careful that the pressure is not too severe, and that the operator's arms do not go beyond the vertical because such movements are of no use and may be unnecessarily bruising, especially to women. They also upset the operator's balance while working. Counting may be more easily learned with the aid of a clock.

If the operator does not hear the air passing without hindrance through the respiratory channels after five or six cycles have been completed, he should immediately draw the patient's tongue forward and be sure that it remains there.

After the first signs of life, evidenced by a quivering of the body, a gasp, return of natural colour to the skin, or movement, artificial respiration should be continued for a little while to assure a firmer hold on life. As soon as the operator is reasonably sure breathing has started, he should confine his activity to the arm-raising motion only, in order not to expel too much carbon dioxide from the blood which is now circulating more normally. Counting is carried on at the same rate, but now the time intervals are two and a half seconds each for inspiration and expiration, making a total of twelve cycles per minute. This is sufficient for the lesser ventilation of the lungs and it ensures that there is sufficient carbon dioxide in the blood to stimulate the respiratory center to greater activity and promote natural respiration as soon as possible.

The pressure on the back of the chest, and the raising of the arms not only force air in and out of the lung, but they also have a beneficial effect on the heart, a matter of great importance. Pressure exerted should be according to the relative size and build of the rescuer and rescued. It stands to reason that a small light operator will need to exert the full weight of his trunk on a large victim whereas a large heavy operator will

need only a portion of his trunk weight to achieve the necessary results with a light slender victim.

If other persons are available at the scene of the rescue, they should do what they can to assist without interfering with the actual resuscitation; they may apply warmth to the victim's body by rubbing (always towards the heart), covering him with borrowed clothes, and procuring other accessories necessary for efficient revival.

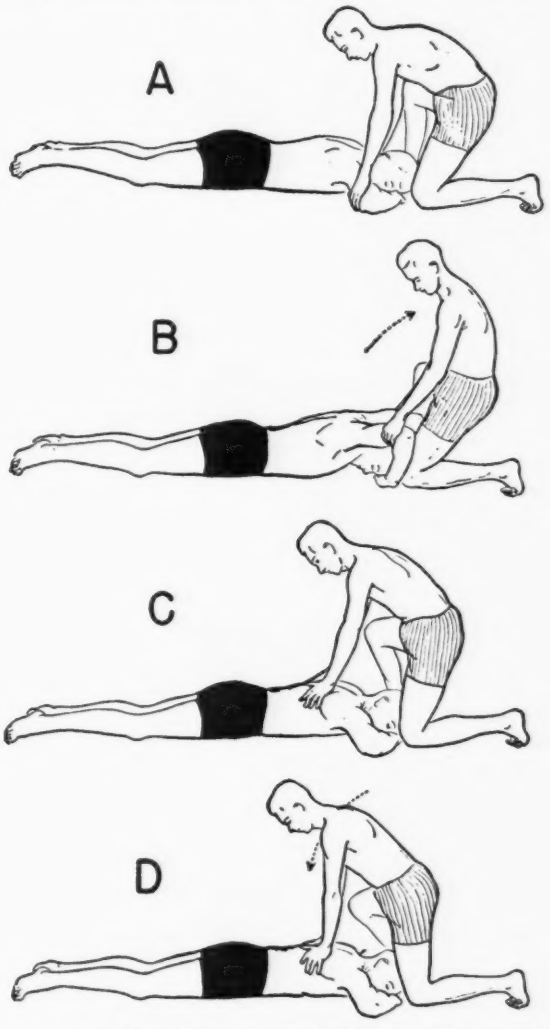
Even if success seems very remote, artificial respiration should be continued without a break until life returns, or a doctor declares the victim dead. If there is no doctor available, the procedure should be carried out (for as long as five hours), until the unmistakable signs of death appear.

When the patient is breathing without assistance, and the heart and respiratory functions are satisfactory, the patient is turned over on his back and circulation improved by brisk vigorous rubbing for five or six minutes. Then he should be removed to a hospital or other medical shelter as soon as possible.

Advantages of the Holger Nielsen Method

For optimal results in the treatment of asphyxia, the method of artificial respiration used should (a) supply an adequate amount of oxygen to the blood, (b) keep the blood carbon dioxide below dangerous levels and (c) require a minimum of teaching, preliminary preparation, and effort (on the part of the operator). A human life may be at stake and for these reasons the choice of method should not be decided on hearsay or personal prejudice, but rather should be based on the results of both clinical and experimental studies in the field of artificial respiration. Many such studies have been carried out over the past few years, and from the data presented, it is fairly evident that the Holger Nielsen method is the most practical when all aspects of administration are considered.

Although the Schafer prone-pressure method had been generally accepted as a standard procedure in the western world since 1903, studies performed on humans and animals in the past decade cast considerable doubt on the ventilatory efficacy of such a single-phase "push" method. From results of experiments on anoxic dogs, Brucer and Swann (12) concluded that unless the volume of tidal air exceeded the physiological dead space* of the respiratory system, there would be no alveolar ventilation. Various observers (13, 14, 15) investigating lung ventilation produced by the Schafer method, reported tidal volumes considerably less than the physiological dead space. The report of Comroe and Dripps (15) also suggested that a higher pulmonary ventilation could be effected by a method which induced both active expiration and active inspiration (push-pull method). These and other reports stimulated further research and the work of Gordon and his associates on warm corpses (6), subjects who had voluntarily suspended respiration (16) and on curarized-anesthetized volunteer adults (17) did much to expose the inadequacies of the Schafer method when it was compared with "push-pull" methods. Gordon and his associates measured air exchange (18), blood oxygen levels and cardiac output (19) in their subjects during the administration of standard and modified Schafer prone-pressure, Holger Nielsen, hip-lift back-pressure, hip-roll back-pressure, Silvester and Eve Rocking, methods of artificial respiration. The average tidal air exchange in pulmonary ventilation, as determined by spirometric measurements, was 485 cc. for the Schafer method, 1,056 cc. for the arm-lift back-pressure method, 1140 cc. for the hip-lift back-pressure method and 1069 cc. for the Silvester. Blood oxygen levels of the subjects were measured after a fifteen minute administration of each



Arm lift-back pressure method of manual artificial respiration (after Holger Nielsen). *A*, placing hands for arm lift. *B*, arm lift. *C*, placing hands for back pressure. *D*, back pressure.

* The space in the breathing passage which just before expiration, still contains fresh, unmodified air.

method. The level fell quite markedly when the prone-pressure method was applied, but remained at about 90% of normal for the other methods. In some cases when the prone Method was used, cyanosis developed and became so acute that the method had to be discontinued. When a push-pull method was substituted, the cyanosis disappeared and the oxygen level rose to about 90%. When the Schafer method is performed at the rate of 12 times per minute, the end-inspiratory volume never returns to the normal resting lung volume, and there is a slight negative pressure. Therefore, if there is any obstruction in the air passages, such as mucus or vomitus, the air inflow is going to be slower. A method which promotes active inspiration will increase the inflow of air.

Studies designed to investigate energy expenditure of operators (20), and pedagogical and performance factors of manual artificial respiration (21) also were carried out by Gordon and his co-workers. In the energy expenditure experiment, nine medical students served as selected operators and each performed five manual methods of artificial respiration on one of three student-volunteer subjects. Methods used were Schafer, Silvester, Nielsen, hip-roll back-pressure and hip-lift back-pressure. The operators unanimously agreed that the sense of fatigue was least with the Schafer Method, and most for the hip-lift back-pressure. The Holger Nielsen method was judged to be slightly more fatiguing than the Schafer, but all operators, except two, felt that they could continue both methods indefinitely. Definite time limitations were reported for performances of the hip-roll back-pressure and hip-lift back-pressure methods. To assess pedagogical and performance factors, 667 Naval recruits and 124 Waves were used as subjects. This study revealed that both the Holger Nielsen, and variations of the hip-lift back-pressure could be taught to Naval recruits in a relatively short time. The Holger Nielsen method was superior to all hip-lift methods in accuracy of performance, ease of of learning and physical ease of performance. The monitors in these experiments placed the Holger Nielsen method above all others.

Karpovich and his co-workers carried out experimental studies of lung ventilation (22), energy expenditure of operators (23) and pedagogical and fatigue factors (24) involved in manual artificial respiration. The subjects were school children, university students, students' wives and nurses. To assess lung ventilation, two highly trained operators were used for males and one operator for females. The methods used were Schafer, Holger Nielsen, Silvester, hip-roll back-pressure, hip-lift and hip-lift back-pressure. Artificial respiration was superimposed on the normal breathing. The results showed that the Schafer method gave about half as much pulmonary ventilation as the other four methods produced. From their work, these investigators concluded that the Holger Nielsen method was the method of choice. Energy expenditure of operators during administration, based on oxygen consumption, was determined for male and female operators. For males, the minute-consumption was respectively, 1) Schafer 547 cc., 2) Silvester 706 cc., 3) Nielsen 947 cc., 4) hip-roll back-pressure 1045 cc., and hip-lift back-pressure 1050 cc.; for women 1) Schafer 445 cc., 2) Silvester, 480 cc., 3) Nielsen 657 cc., 4) hip-lift back-pressure 713 cc., and hip-lift back-pressure 746 cc. In the third study, using 67 college and 100 academy students, order of increasing difficulty with respect to learning and fatigue were, 1. Schafer, 2. Nielsen, 3. Silvester, 4. hip-roll back-pressure and 5. hip-lift and hip-lift back-pressure.

Whittenberger and his co-workers (25) measured instantaneous air-flow rates and pulmonary ventilation volumes during manual artificial respiration on eight apneic patients, most of whom were comatose from intracerebral hemmorrhage. They found that the Schafer method was inadequate. The other two methods used, the Nielsen and the hip-lift back-pressure, afforded excellent ventilation.

Nims (26) and his co-workers, using four non-breathing and eight apneic patients, found that of the five methods applied, the hip-lift procedure produced greatest tidal volumes, and the Schafer the least. The Nielsen method, while producing less ventilation than the hip-lift methods, was considered to be convenient and practical for administration over long periods of time.

Summary and Conclusion

Since lung ventilation and maintenance of oxygen level in the blood are the prime factors in successful resuscitation by artificial respiration, it is evident from the studies mentioned that the Holger Nielsen method is superior to the Schafer method in that it gives greater lung ventilation and maintains the blood oxygen at a much higher level. Although the hip-lift back-pressure methods effect greater lung ventilation than the Holger Nielsen, they are more difficult to learn and perform, are more fatiguing and do not produce a significantly greater lung ventilation, nor do they maintain a higher blood oxygen level. However, they are superior to the Schafer method and, where feasible, may be applied in certain situations which might warrant their use.

The acceptance of the Holger Nielsen method does not discredit the fact that the Schafer method has been responsible for the successful resuscitation of a large number of asphyxiated victims who may otherwise have expired, but it is quite possible that a greater number would have survived with intelligent use of the Holger Nielsen and other push-pull methods.

Whatever the method used, it should be thoroughly learned and practiced until it can be applied automatically.

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Some Fundamental Air Pollution Problems

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TECHNICAL interest in air pollution by industrial effluents and radioactive wastes continues to grow in the post-war period. This is attested by the considerable number of scientific conferences and lectures which have been held within the past three years. Among these may be mentioned the symposia sponsored by the American Chemical Society at San Francisco in

March 1949; the Stanford Research Institute at Pasadena, Calif., in November 1949 and May 1952; the U.S. Technical Conference convened at the request of President Truman at Washington, in May 1950, and the Air and Stream Pollution Symposium at the XIIth International Congress of Pure and Applied Chemistry, New York, in September 1951. In Canada, current interest in this problem is shown by the work of the Committee on Atmospheric Pollution sponsored by organizations representing industry, the engineering profession and some government technical departments. A number of lectures by authorities in this field were given at Ottawa during the winter of 1952, under the auspices of the Department of National Health and Welfare.

These technical conferences have been of great service in making available to science and industry the outstanding developments in such diversified fields as physical and chemical properties of gaseous and aerosol contaminants, analytical methods and instrumentation, methods of collection, control and recovery of effluents, meteorology in relation to dispersion and diffusion, effects on agriculture and health, regulations and legislation in relation to air pollution control. A review of the papers presented at these conferences and of the recent literature reveals the complexity of the problem and the great gaps in our present knowledge of the properties, behaviour and physiological effects of the numerous substances which occur in the atmosphere over large centers of population. It is the purpose of the present paper to summarize, briefly, the status of our present knowledge and indicate the paths of research which should be explored if further fundamental progress is to be made.

1. *Sampling, Analysis and Instrumentation*

The physical and chemical properties of pure gases and homogeneous aerosols have been studied extensively. But caution must be exercised in the application of techniques, developed in such studies, to the complex gaseous and heterogeneous aerosol impurities of the atmosphere. Gases and vapours originally discharged in the pure state may undergo chemical inter-action with other impurities. oxygen of the air, or photochemical decomposition. Sulphur dioxide in moist air undergoes slow oxidation to sulphuric acid, but this reaction may be catalyzed by metallic oxide impurities, oxides of nitrogen and sunlight (2, 6). Unsaturated hydrocarbons may be converted to ozonides or peroxides after release to the atmosphere. These secondary reactions may convert innocuous compounds to obnoxious irritating substances capable of producing intense lachrymation (8). Sulphuric acid mist formed from sulphur dioxide may be a major factor in producing low visibility. Aerosol particles, either liquid or solid, which are most effective in the scattering of light and reducing visibility, are of the size range of 0.3 to 0.6 micron diameter (9). Such particles, because of their low settling velocity, remain suspended in the air for a long time and are dispersed in the atmosphere almost like a gas. Industrial discharges of smoke, mist and fume

1

2

3

4

Air Pollution in Windsor, Ont.

Fig. 1. View at 5:30 a.m. standard time shows heavy smog under temperature inversion conditions with layering or stratification of pollution.

Fig. 2. About 6:30 a.m. – visibility is decreasing and pollution layers are becoming different and homogeneous.

Fig. 3. About 7:30 a.m. – visibility slightly better, but smog still dense.

Fig. 4. About 10:00 a.m. – the smog has been dissipated by increased wind turbulence.

contain a considerable percentage of particles in this size range.

Contaminants in the atmosphere created by the varied activities of man may be classified, simply, into gases and vapours, which include the true gases and compounds which have boiling points below about 300° C. and aerosols consisting of small solid or liquid particles which form finely divided suspensions in air of low settling velocity and exhibit Brownian movement. Particles larger than 10 microns in diameter settle out of the air fairly rapidly according to Stokes' law and form the major portion of deposited matter. Gases and vapours contribute in large measure to the corrosion of metals and deterioration of stonework and building structures. Sulphur dioxide and hydrogen fluoride are responsible for considerable damage to agricultural crops and forests. Fluorine compounds have caused extensive damage to livestock. The chemical properties of gases and vapours are therefore more important than their physical properties. The reverse is true for aerosols, however. Physical properties of aerosols such as particle size, stability, electrostatic properties, rates of diffusion and coagulation determine the intensity of physiological effects.

The analytical chemist in his studies of the nature and composition of air contaminants has at his disposal all the newer techniques involving micro-analysis, colorimetry, fluorometry, light and electron microscopy, x-ray, ultraviolet, visible and infrared spectroscopy, mass spectrography, electrometric and conductometric methods, However, there is a great need for a standardized approach in this field to cover methods of sampling the air, nomenclature and units in reporting data. More research is necessary in determining the limitations of various sampling methods, instruments and techniques. More knowledge is required of the nature of organic pollutants. Chromatographic adsorption methods may be of great value in this regard. Difficulties are encountered in the separation and analysis of sulphur-containing components such as mercaptans, hydrogen sulphide, sulphur dioxide, sulphur trioxide and sulphuric acid. The properties of aerosols may be influenced and altered by the method of collection and therefore it is important to develop more fully those optical methods capable of measuring properties *in situ*, such as light scattering. The standard impinger, widely used in the collection of aerosol samples in the field of industrial hygiene, is inefficient in the submicron range.

Emphasis is being placed on the continuous monitoring of pollution for both radioactive and industrial wastes. This is because meteorological factors which influence the dispersion and dissemination of contaminants, the intensity and frequency of occurrence of ground fumigations, vary with the time of day and season of the year. In Great Britain, where studies of urban air pollution have been pursued continuously for many years, the major emphasis is on instruments and sampling methods which yield long-time average values, daily and monthly averages for sulphur dioxide and monthly averages for deposited matter. However, the Owens atmospheric pollution recorder yields a continuous 15-or 30-minute record of smoke contamination by filtering the air through a filter paper which is rotated automatically, yielding a stain which can be related, empirically, to the intensity of pollution. In America, short-time averages are considered important and stress is placed on recording instruments of this type. Short sampling periods are necessary for locating sources of pollution, assessing the hazards to agricultural crops where damage is caused by short period emissions of higher than average concentrations, and also in process control where operations are being conducted so as not to contravene air pollution control regulations. The Thomas autometer (11) is a valuable instrument for measuring instantaneous and continuous values of gaseous pollution.

The problem as to what constitutes a good index of general pollution depends a great deal on the nature of industrial operations and wastes discharged to the atmosphere in the area under investigation. Where the problem is one of pollution from the products of combustion of solid fuels from domestic and industrial heating furnaces and from power plants, the sulphur dioxide concentration of the air, or its equivalent, is a good index of the degree of contamination. This is also true for operations involving smelting and refining of sulphide ores. In operations involving the production of aluminium and phosphate fertilizers, hydrogen fluoride is the most serious pollutant likely to be encountered. Oxides of nitrogen are formed in combustion of some fuels, by oxidation of ammonia, and may be present in refinery waste gases and effluents from chemical plants. Numerous other contaminants are released in special manufacturing processes. As a general index of smoke and aerosol contamination in the air of urban communities, the intensity of staining of paper or other filters, or the mass concentration of particulates, determined by filtration, are methods employed frequently. Number and size distribution of particles may be determined after collection by methods involving impingement, thermal or electrostatic precipitation.

Various committees have been formed recently to standardize sampling and analytical methods, assess the value of techniques and instruments employed in studies of air pollution and evolve a uniform system of nomenclature and units. Among these may be mentioned Committee D-22 on Methods of Atmospheric Sampling and Analysis of the American Society for Testing Materials and the Committee on Atmospheric Pollution, Council on Industrial Health, American Medical Association. An excellent review of analytical methods used in the study of air pollution has been

presented by Kay (4). The recently published Proceedings of the U.S. Technical Conference on Air Pollution contain about 52 papers in the sections dealing with analytical methods, instrumentation and equipment for control and recovery of effluents (5).

II. *Effects on Vegetation*

The effects on agricultural crops of many chemical impurities in the atmosphere are often obscured by physiological and pathological symptoms of leaf breakdown which make the evaluation of plant injury a difficult subject. Plants are more sensitive to some gases, such as sulphur dioxide, fluorine and ethylene, than are animals. On the other hand, animals are more sensitive to others, such as hydrogen sulphide. The effects of sulphur dioxide on vegetation have been investigated more extensively than any other contaminant because of the extensive damage caused in earlier years by smelter operations. A considerable amount of knowledge is available therefore on the permissible limits for susceptible species under various atmospheric conditions. The extent of injury to the leaves depends upon the rate of absorption of the gas through the stomata and the time of exposure, as well as the concentration and other external factors (1, 3, 10).

The effects of fluorine-containing impurities in air on vegetation are in a less satisfactory state and, in spite of the large number of investigations carried out in the last five years, many problems remain obscure. Some plants, like gladiolus, are so susceptible to fluorine that the order of toxicity is from 10 to 100-fold greater than that for sulphur dioxide. The concentrations have to be determined in parts per billion rather than in parts per ten or 100 million. Other plants can store up relatively large amounts of fluorine in the leaves without damage thereto, but become toxic to livestock if used for fodder (10).

Recently, in the Los Angeles area, a form of damage to endive, spinach, Romaine lettuce and many other species including cut flowers, entitled "smog damage" has been reported for several years, resulting in serious economic loss. This form of damage occurs during periods of smog in summer and autumn when prolonged, non-diurnal temperature inversions, accompanied by winds or low velocity, cause the effluents from this urban and industrial area to accumulate in higher than normal concentrations. It appears to be primarily due to absorption by the leaves of organic ozonides, peroxides and acids occurring as contaminants in the air. (8, 10). However, much more information is necessary before the several forms of this type of injury can be accurately evaluated as to cause and effect.

Very little is known about the action of oxides of nitrogen on vegetation. Apparently such oxides are much less toxic to plants than sulphur dioxide but occasionally injury has been caused by emanations from industrial establishments manufacturing nitric acid or using this acid in nitration processes. These symptoms appear as yellow, brown or brownish black discolorations on the leaves, depending upon the species.

III. *Health Aspects*

Our knowledge of the effects of various air pollutants on plants is in a much more satisfactory state than that of acute and chronic exposure on human health. Although acute effects such as the air pollution disasters in the Meuse Valley, Belgium, in 1930 and at Donora, Pa. in 1948 are a matter of record, the exact cause in each case is still unknown. The Meuse Valley episode was originally ascribed to the build-up of sulphur dioxide and its oxidation product in relatively high concentration in the smog produced in the valley during the five-day period of temperature inversion (12). Later, however, it was thought that fluorine compounds emitted from a number of industrial chimneys in this area may have been a contributing factor. Again, at Donora, the cause remains obscure although sulphur compounds are mentioned as possibilities. Following the disaster at Donora, an intensive study of air contaminants in this region by the U. S. Public Health Service revealed many common irritant gases and products from combustion of fuels, zinc and steel plants, and miscellaneous industry, but at levels far below those which could induce an acute respiratory episode. The Donora Report (13) stressed the significance of a synergistic effect in air pollutions whereby the combined influence of several toxicants occurring simultaneously may be far greater than the additive effect of individual contaminants.

Where the toxic agent predominates, it is not too difficult to determine the cause in a given situation. This was illustrated in a disaster attended by 21 deaths at Poza Rica, Mexico, in November 1950 after accidental discharge of a large amount of hydrogen sulphide from a refinery. Other well known physiological symptoms are those caused by inhalation of arsenic, silica dust, fluorine compounds and beryllium in polluted air.

The chronic effects of air pollution are not so well defined and there is, at the present time, a dearth of convincing evidence in support of the view that repeated exposures to low concentrations of common aerosol contaminants and irritant gases may be a predisposing factor to respiratory infections. Baetjer has reviewed, recently, the status of the subject regarding the effects of chronic exposure of air pollutants on acute infectious respiratory diseases (7). It is concluded that the data available are entirely insufficient to draw any definite conclusions. However, there is the evidence of frequent eye irritation during smog visitations in the Los Angeles area (8), and the extreme sensitivity of asthmatics to irritant gases, such as sulphur dioxide, in low concentrations (13). Statistics are also available on the increase in the death rate from respiratory disease

during fogs in industrial communities in Great Britain (14).

It is evident that the effects of air pollutants on the health of humans and animals in the concentrations and exposures under environmental conditions approaching those of large industrial cities have not been investigated sufficiently. In the international pollution problem involving the Windsor-Detroit area, a joint study is being undertaken, under a Board of Technical Advisers to the International Joint Commission, to determine the influence of the existing environment of this highly industrialized zone on morbidity and public health. The study is based on areas of high and low pollution which have been delineated by data from continuous field sampling stations.

In the field of public health there is obviously need for fundamental research on: (1) physiological effects of contaminants found in the air on body tissues and evaluation of the synergistic factor, (2) animal experimentation on effects of such toxicants on susceptibility to infectious diseases and to irritation of sensitive membranes, (3) controlled epidemiological and morbidity studies of not only the comparatively healthy working population, but of children and people over 60.

More information is also necessary on permissible toxicological limits of exposure and on the physicochemical relationships between fine aerosol particles of large surface area and gases found in urban atmospheres. The role of such particles in adsorption and catalysis of reactions involving gases and vapors may have to be evaluated in laboratory studies in order to determine the nature of the complex environments which will warrant future study.

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Health Education in Industry

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The health and welfare of people in industry has, for many years, assumed international importance. The growing interdependence of nations and the present race to industrialize the underdeveloped areas of the world have served to accentuate this.

In Canada, during World War II, the health status of recruits in the armed forces was responsible for a relatively high rate of rejections in the young adult population. Health records in industry have helped to point up the most usual health needs among those who are employed. In spite of the health services which have been built up during this century, we find many people with conditions which could be alleviated, controlled or corrected. Many people have known of their health condition and of the means of correction, but have not secured the necessary care. For some, there was no help at the time the condition was discovered and facilities now available have not been used.

Observation of recurring health needs within an industry, study of the general health needs in the community and a knowledge and understanding of means of fulfilling those needs will help to provide a basis for health teaching as a part of nursing in industry.

Health has been defined in a variety of ways, but the definition proposed by the World Health Organization provides a good foundation for the development of health education in industry. It states that health is ". . . . . a state of complete physical, mental and social well-being, not merely the absence of disease or infirmity . . . . . which makes possible the highest quality of effective living and of service." Two things become evident when we study this definition. Firstly, health

is to be protected and preserved for a reason—effective living and service. Secondly, the definition has to do with the potentialities of each individual, rather than comparison of one individual with others. The complexity of assessing individual abilities, interests and motives must be considered by the nurse in industry, if she is to be effective in her health teaching.

The purpose of health education includes promotion of health and safety and preparation for healthful living. It becomes abundantly clear that in our society which fosters individual freedom and individual responsibility commensurate with that freedom, this purpose must be achieved through the development of self direction. This must be kept in mind in the planning, carrying out and evaluation of health teaching in industry.

Even though the primary purpose of health education in industry be stated in terms of production, the far reaching implications and long range view cannot be overlooked. The industrial nurse must give some thought to future generations and the expanding needs in our society. Do we have more than enough people today with limited choice of occupation, and at the other end of the same scale too few people available for a great variety of essential work? What steps are necessary to overcome this and what contribution may the nurse in industry make?

We know that the good health of the family has a very important influence upon the general welfare. For example, the good health of the mother serves as a protection to the children. The good health of the father improves his opportunity for continuous employment, eliminates the high cost of sickness and helps to insure better living conditions for the family. Worry over other members of the family is reflected in the work of those employed in industry. The industrial nurse soon finds that her interest must extend beyond the plant itself, if she is to understand some of the real causes of sickness, accident and absence from work.

How does health education in industry come about? This depends in part upon the time that is available. In some industries health education has become a vital part of the programme. It receives special consideration and time is set aside in the working day for lectures, group discussion and the like. In other industries no such provision is made. Be that as it may, health education may become an integral part of the nurse's work. Many opportunities arise in her interviews with individuals and groups; and visual materials, such as posters and literature may be used to strengthen her teaching. In planning health education she uses every opportunity to promote interest and active participation throughout the industry.

Although, in the majority of industries, the nurse will probably find that her greatest opportunity for health education lies in individual teaching, this does not mean that group work should be overlooked. Some problems are tackled in a much more effective way by groups than by separate individuals, especially if the group represents a variety of points of view.

Who needs health education? The whole industry is involved in some parts of the health programme and health education becomes very important in relation to the policies of the industry. For example, the chest x-ray survey may be used to develop understanding and self-direction. If a survey is to include the entire industry, there will be a big job of work to do before the survey begins. Careful explanation and prepararion should be made so that individuals and groups will have time to consider the purpose of the survey, the significance of early diagnosis, care and treatment of tuberculosis, community responsibility in maintaining adequate resources for prevention and treatment of tuberculosis and many other questions which may arise and require thoughtful consideration. Effective control of this disease depends upon the sustained interest of the community. The attitude toward the disease and the acceptance of individual responsibility are important. The nurse in industry will find many opportunities to influence the development of constructive attitudes which, in turn, help people toward growing self-direction. This cannot be achieved in a day; it happens little by little and depends to a large extent upon the skill of the nurse in helping others to make their own decisions. They may need further information, or an opportunity to talk things over. They may be confused by hearsay and the premature publicity given to new and untried drugs and treatments. The nurse must be aware of what is happening in the field of research and experimental work and she must know the significance of what the general public is reading in popular magazines, if she is to help clarify thinking and overcome major misconceptions. This is

Careful preparation should be made . . .

but one example of the opportunity for health education in industry.

In addition to health policies which may be instituted for the whole industry, there may be groups within an industry who have special needs. For example, special hazards may be found in particular departments. The awareness of these hazards may not serve to create safety for the employee. He may even become less concerned about the hazards as he becomes more familiar with the work. This presents one of the most important challenges to the nurse in industry. Self-direction is of utmost importance in the promotion of safety. Rules and penalties create a negative influence which in themselves cannot guarantee safety. The group involved in the hazardous process must find ways of promoting safety. Individual behaviour is chiefly concerned; motivation then becomes basic and this depends upon an analysis of feelings and attitudes in addition to understanding of the requirements for safety. The rules may grow out of group thinking and discussion, and the observance of these rules will depend upon their acceptance by members of the group and the group as a whole. In other words, there would result greater individual responsibility and greater group responsibility. Members of the group would help each other to abide by safety regulations throughout the working period.

Health conditions found among employees provide further opportunity for individual and group teaching. Special age groups may present special hazards which require particular care on the part of the nurse in order that adequate means of protection may be observed. The executive group may have special needs in relation to health as well as to the more thorough understanding of the relationship between health of the employee and production.

Foremen are in a position to observe early signs of illness because they are so well acquainted with the individual employees in their group. If we are to achieve the purposes of a health service, it will be increasingly necessary to discover incipient illness as early as possible. Like the teacher in the classroom, the foreman is able to see slight deviations in behaviour which may indicate the very early stage of illness. Without the foreman's help, this might be overlooked until it interfered with the employee's ability to work.

Committees with special responsibilities relating to health and safety may present special problems which the nurse in industry can help to tackle. The nurse's understanding of human needs and behaviour, community and social customs, will help her to work effectively with other members of such committees. She may find resources in her community which she can use to develop this understanding and skill, or she may have to depend to a very large extent upon her own reading and study.

Health programmes that are going on in the local community, in the province and over the country as a whole, may give direction to the health education programme from time to time. To name only a few, cancer, safety, and immunization are particularly important to the industrial worker and his family. The teaching programme should be a continuous one, but special focus upon particular topics from time to time will serve to add variety and strengthen the day by day programme.

How will the industrial nurse prepare herself for health education? Reading is the most universal way in which the industrial nurse can maintain her awareness of developments in nursing, health, medicine and related fields which affect her services. Keeping in close touch with other nurses in the hospital and public health field will enable the industrial nurse to follow through on service for patients. Discussion and comparison of experiences will often help the industrial nurse to evaluate her own service and make improvements. This is particularly true, if the nurse is working alone. There may be resources within the community which are readily available to the industrial nurse. These may be used in developing a programme in the professional association, or regular courses in the university and other institutions may be attended.

It has become increasingly important for human beings to learn how to get along together in harmony and understanding; to try to accept the other person's reactions and attitudes in an attempt to reach a common agreement. This has meaning for the industrial nurse in her efforts to promote health education. She must take account of attitudes, understand their significance and find ways to guide people to a healthful way of living because there is a compelling motive. Theodore Roosevelt once said, "The best prize which life offers is a chance to work hard at work worth doing." This is a basic tenet of health and happiness.

Parathion Exposure and Cholinesterase Response of Quebec Apple Growers

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Parathion has now been used in control of orchard insects for three years in the United States and two years on Canada. During this period, fatalities and serious illness attributed to parathion have been reported season by season.

The tonnages of parathion which have been used in the field, without ill-effect, demonstrate that under some sets of conditions the compound can be safely applied. That there exist sets of dangerous conditions is indicated by the reported cases of death and illness including, as they do, some proportion of positive diagnoses. Poisoning has been claimed to have taken place at one stage or another in manipulation of the material from the point of opening the bag to the ultimate possibility of contact with material residual at thinning or suckering time. It is clear that a differentiation between safe and dangerous conditions can only be made from precise data on the relation between parathion exposure and biological effect.

The literature which has been laid down on the subject is diversified, but not yet adequate to establish a maximum safe level of exposure. DuBois and coworkers (1), Lehman (2) and Hazelton and Gardocky (3) have dealt with the mammalian toxicity of parathion. A number of authors have described methods for determining cholinesterase in blood and tissue (4-11). Hamblin and Marchand (12) reported a capillary version of the Michel test and Metcalfe (13) a similar adaptation of the Hestrin method. Cholinesterase in health and disease has been investigated by Vahlquist (11), Sabine (14), Savitsky et al (15), Michel (8), Callaway and coworkers (16), recently Hutchinson and Widdowson (17) and others (5, 6, 11, 18-27).

Grob, Garlick and Harvey (28), Mendel and coworkers (29), Barnes and Davies (30), Hamblin and Marchand (12), Griffiths et al (31) and Williams and Griffiths (32) have reported on symptomatology of poisoning and levels of cholinesterase in blood of persons exposed to underdetermined concentrations of parathion. Mountain et al (33) have provided a method for determining the metabolite, paranitrophenol, in urine. On the environmental side, Bradley and associates (34) have estimated concentrations of parathion in the air of California citrus groves. Finally, Brown and Bush (35) in 1950 estimated levels of parathion in the air of a processing plant and determined cholinesterase levels in blood of exposed workers.

The experiments reported in this paper combined study of parathion exposure and cholinesterase response of orchard workers in Quebec for the purpose of ultimately establishing the safe level of exposure to the insecticide.

PARATHION IN THE AIR OF QUEBEC APPLE ORCHARDS

The St. Hilaire-Rougemont orchards are sprayed for approximately two days, at ten day intervals from early May through June. Our environmental measurements during the 1951 season involved determining the air-borne parathion during and after spraying of 15 per cent wettable powder in the concentration 0.75-1.5 pounds per hundred gallons of water and dispersed at the rate of 300-400 gallons per acre. This measurement described the respiratory exposure and, to some degree of approximation, the surface exposure, for high concentration in air leads to high concentration on adjacent objects such as skin or clothing. Measurements were made in four orchards of the St. Hilaire-Rougemont area from the pink bud cover for plum curculio control between May 18-20 through the final cover of June 18. The hand type or rocking type mechanical sprayer was employed in all orchards.

Air Concentrations during Spraying

Sampling of air for parathion was carried out using impingers and fritted glass bubblers in series, charcoal-purified alcohol and velocities of 1.5 litres

TABLE 1

PARATHION SPRAY CONCENTRATIONS—ST. HILAIRE 1951

Operator Breathing Zone — 15 Percent Wettable Powder

Orchard	Date	Formula	Parathion in Air γ per litre	Temp.	Humidity	Air Movement
Marsan	5 18 PM	1P 10S 100	5.5	66	42	S.E. 5
Marsan	5 19 PM	"	2.0	73	42	S.W. 6
Marsan	5 19 PM	"	4.0	76	42	S.W. 3
Cardinal	6 1 AM	3P 20S 250	2.5	70	58	S.W. 10
Cardinal	6 1 AM	"	7.5	73	58	S.W 12
Cardinal	6 1 AM	"	15.0	75	52	S.W. 13
Petit	5 28 PM	¾P 10S 100	14.0	80	50	N.E. 16
Petit	6 18 PM	1.5P 8MP 100	2.4	78	53	S.W. 2

TABLE 2

PARATHION SPRAY CONCENTRATIONS—ST. HILAIRE 1951

LAROSE ORCHARD

Operator Breathing Zone 1P*/8S/100 Gal. Water

Date	Parathion in Air γ per litre	Temperature	Humidity	Air Movement
5/29 AM	11.5	73	58	N. E. 13
5/29 PM	5.5	71	55	N. 13
5/29 PM	14.0	72	53	N. 13
5/29 PM	10.0	69	60	N. 13
5/30 PM	4.0	64	72	S. 6
5/30 PM	3.5	64	72	S. 6
5/30 PM	4.0	64	72	S. 6

*15 Per Cent Wettable Powder.

per minute. Efficiency of collection was pretested. The ultraviolet spectro-photometric method of Hirt and Gisclard (36) was employed to determine concentration of parathion in the collection solvent. A blank correction, low in magnitude, was calculated by sampling air several miles from the orchards.

It was observed that spraying was timed more to the need for insect control than to the suitability of weather. As a result, measurements cover a variety of conditions ranging from down wind spraying with little operator exposure to up wind spraying with heavy blow-back and high exposure. Table 1 shows concentrations of parathion in air within a few feet of spray operator breathing zone. The concentrations were found to range from a low of 2 to as high as 15 micrograms per litre. As will be noted high concentrations in general occurred when spraying during windy conditions, in which case the contamination of skin and clothing was also high.

Table 2 shows further high air concentrations during spraying under windy conditions. Effects of temperature and humidity could not be differentiated from the influence of air movement. It is of interest that a concentration range of 0.1-0.8 micrograms per litre was found by Brown and Bush (33) in a processing plant. Bradley and associates (32) have reported concentrations of as high as 0.3 micrograms per litre during spraying in California citrus groves.

TABLE 3

PARATHION CONCENTRATIONS AT TANK FILLING—St. HILAIRE

LAROSE ORCHARD 1951

Operator Breathing Zone 15 Percent Wettable Powder

Date	Parathion in Air γ per litre	Temperature	Humidity	Air Movement
5/30 PM	15.6	64	72	S. 6
5/30 PM	25.5	64	72	S. 6

TABLE 4

RESIDUAL PARATHION IN AIR—ST. HILAIRE 1951

MARSAN ORCHARD

At Four Feet Above Ground Formulation 1P/10S/100 Gal.

Test	Date	Time	Parathion in Air γ per litre	Temp.	Humidity	Air Movement
Spraying	5/18	5.18 P – – 5.44 P	5.5	66	42	S.E. 5
Residual	5/19	10.27 A – – 11.23 A	0.34	73	42	S.W. 5
Residual	5/19	2.21 P – – 2.30 P	1.1	73	42	S.W. 6

TABLE 5

RESIDUAL PARATHION IN AIR—ST. HILAIRE 1951

MARSAN ORCHARD 2

At Four Feet Above Ground Formulation 1P/10S/100 Gal.

Test	Date	Time	Parathion in Air γ per litre	Temp.	Humidity	Air Movement
Spraying	5/19	3.05 P – – 3.14 P	2.0	76	42	S.W. 3
Spraying	5/19	3. 30 P – – 4.00 P	4.0	76	42	S.W. 3
Residual	5/20	11.12 A – – 12.08 P	0.4	71	56	S.W. 5
Residual	5/28	11.53 A – – 12.53 P	0.2	80	50	S.E. 11
Residual	5/28	12.45 P – – 12.55 P	2.5	80	48	S.E. 11

TABLE 6

RESIDUAL PARATHION IN AIR—ST. HILAIRE 1951

PETIT ORCHARD

At Four Feet Above Ground Formulation ¾P/10S/100 Gal.

Test	Date	Time	Parathion in Air γ per litre	Temp.	Humidity	Air Movement
Spraying	5/28	4.00 P – – 4.10 P	14.0	80	50	N.E. 11
Residual	5/29	3.30 P – – 5.30 P	0.09	70	55	N.E. 13
Residual	6/18	3.55 P – – 9.00 P Sprayed at 3.40 P	0.10	78	53	S.W. 3
Residual	6/19	2.00 P – – 8.00 P	0.03	80	50	S.W. 10→ S. 5
Residual	6/19	3.00 P – – 8.00 P	0.04	80	50	S.W. 10 S. 5
Residual	6/20	11.50 A – – 9.00 P	Trace	84	40	Gale S.E. 12 S. 16
Residual	6/20	11.50 A – – 9.00 P	Trace	84	40	Gale S.E. 12 S. 16

Tank Filling

Owing to the emphasis which has been placed upon the danger to operators at tank filling, tests were conducted while 15 per cent wettable powder was being added. Table 3 shows values derived from two tests in which the dust cloud rose to operator's breathing zone. It will be noted that concentration is not excessively higher than during spraying with blow-back. In view of the very short time required to dump bags in formulating the mixtures used at St. Hilaire, and because dust cloud is carried past the breathing zone in a few seconds, the exposure during filling can probably be considered of secondary importance.

TABLE 7

RESIDUAL PARATHION IN AIR—ST. HILAIRE 1951

LAROSE ORCHARD

At Four Feet Above Ground Formulation 1P/8S/100 Gal.

Test	Date	Time	Parathion in Air γ per litre	Temp.	Humidity	Air Movement
Residual Sprayed	5/28 A.M.	3.00 P – – 4.30 P	0.83	80	50	N.E. 11
Residual	5/28	5.00 P – – 6.15 P	0.55	80	50	N.E. 16
Residual	5/29	10.30 A – – 12.00 P	0.25	73	58	N.E. 13
Residual	5/30	10.00 A – – 5.00 P	0.08	60–80	52–40	N.5→S. 6
Residual	5/31	10.00 A – – 12.30 P	0.05	78	55	S.2
Residual	6/6	10.00 A - – 5.00 P	0.12	74	50	S.W. 11→ W. 16

Residual Parathion

From the inception of parathion there has been concern with regard to the danger of working in sprayed areas. Table 4 shows two residual levels determined at a point the morning after spraying while spraying was being carried on some three hundred yards away in area 2 of this orchard. In view of findings shown in Tables 6 and 7, it is considered that the results in Table 4 have been augmented by drifting spray. Table 5 for Area 2 of the Marsan Orchard discloses residual parathion in air concentration 0.2 micrograms per litre a week after spraying but a second value at this time, running 2.5 must be considered the result of drifting spray from the neighbouring Petit Orchard for which spraying and residual values are shown in Table 6. These values are to be regarded as high for residual air-borne parathion derived from that deposited on foliage and evaporating into the atmosphere. These tests demonstrate the difficulty of precise air pollution assessment when contiguous areas of pollution exist.

Table 6 giving residual findings on the Petit Orchard shows that afternoon spraying under windy conditions p.m. 5/28 yields a residual value of 0.09 the day following and 0.10 nearly three weeks later, no nearby spraying taking place at these times. The values of 6/20 which were obtained following a 6/18 spraying demonstrate that high wind velocity cleared parathion out of the air. Table 7, for the Larose Orchard shows higher residual values following spraying and re-emphasizes the important influence of wind in the level of parathion that continues in orchard air. These levels match the findings of Bradley and associates in California citrus groves.

It would appear that parathion in detectable amounts will linger in orchards for a considerable period following spraying. This aspect deserves further investigation particularly tests on leaves and fruit, as it carries implications for safety during thinning operations where skin contact as well as respiratory exposure are involved.

EFFECT OF EXPOSURE ON BLOOD CHOLINESTERASE

The experiments so far described have established the air level of parathion in the orchards under study: These measurements have also provided an index of the surface exposure and indirectly skin absorption. The effect of this exposure for a few days in each ten over a two-month period may now be presented in terms of the change in blood cholinesterase of a group of exposed persons.

The capillary version of the Michel test as adapted by Hamblin and Marchand (12) was employed in estimations on the plasma and red cell fraction of blood. There were three blood samplings during the spray period and two further samplings in July and October to provide a control level. Inevitably gaps in the data occurred owing to inability to secure blood on certain

Mr. J. P. Windish of the Industrial Health Laboratory setting up apparatus to measure parathion evaporating off newly sprayed apple trees at St. Hilaire, Quebec.

occasions, and other eventualities of this kind. The results are expressed in pH units rather than percentage of a "normal" figure. Reference may be made to recent interest in the coexisting cholinesterase of blood. The Michel test includes techniques for measuring pseudocholinesterase in plasma and true cholinesterase in the red cells. It is to be stressed that the △pH values derived from the Michel test may not be cross-comparable from laboratory to laboratory at this stage of knowledge of the parameters of the test.

The Exposed Group

The group consisted of one female and thirty-two male adults chosen on a basis of experimental convenience. Age level was largely young adult. Specific age and sex distribution were not sought in view of the negative findings of Callaway and co-workers (16) on these aspects. Information on general health experience was collected. Personal protective measures featured dungaree coveralls, rubber boots, fabric and rubber caps and fabric mitts. Rubber clothing was worn in only a few cases. Respirators were indifferently used and variably cared for by roughly one third of the group. In summary, personal protective measures matched the level of comfort and practicability typical in other orchard areas of the country.

TABLE 8

CHOLINESTERASE LEVELS FOR CONTROL GROUP
OTTAWA 1951-52

Michel Method — Capillary Technique

	AUGUST			OCTOBER			FEBRUARY		
	η	Level	S.d.	η	Level	S. d.	η	Level	S. d.
Plasma	36	0.83	±0.19	38	0.82	±0.19	38	0.88	±0.19
Red Cell	34	0.80	±0.12	38	0.80	±0.11	37	0.78	±0.10

The Control Group

At the commencement of these experiments in May 1951, the literature provided only limited information on normal variation in plasma and red cell cholinesterase. Furthermore, normal levels of cholinesterase reported in the literature were based on different units of measurement. A control group socio-economically comparable, was therefore constituted in Ottawa so that there would be an index against which to compare recovery levels of the exposed group at St. Hilaire. For this purpose cholinesterase in plasma and red cells of thirty-nine Ottawa civil servants was estimated on three occasions. This group was largely of young adult age.

Table 8 summarizes cholinesterase levels for the control group. It will be noted that red cell variation from individual to individual is considerably lower than the variation of plasma. Coefficients of variation calculate to 22.6 percent for plasma and 14 percent for red cells. This finding confirms the recently published work of Callaway and coworkers (16) who found coefficients of variation 21.7 percent for plasma and 15.4 percent for red cells. Agreement of period averages is good as were frequency distributions which will not be shown. Student's t test applied to the plasma levels for October and February which differed by 0.06 yielded a non-significant P value of 0.16.

To provide more searching statistical treatment, analysis of variance was also carried out on plasma values of thirty-five subjects for whom there were no gaps in data. This yielded a difference between subjects significant at 1 percent significance level and a small difference between periods significant at 5 percent significance value. In the case of red cell results only a difference between subjects materialized.

In summary it may be stated that average plasma values for the group varied from period to period by a maximum of 7 percent (October-February) and average red cell values by not more than 2.5 percent.

TABLE 9

PLASMA CHOLINESTERASE LEVELS FOR SPRAYERS
ST. HILAIRE—ROUGEMONT 1951

Michel Method

Sampling Date	Number of Samples	Average Level	Standard Deviation
May 30—June 8 1	33	0.78	±0.14
June 12—June 18 2	25	0.77	±0.14
June 16—June 22 3	27	0.74	±0.15
July 25—July 27 4	27	0.80	±0.19
Oct. 3—Oct. 10 5	24	0.85	±0.17

Significance of Difference between 3 and 5—P = <0.016

TABLE 10

RED CELL CHOLINESTERASE LEVELS FOR SPRAYERS
ST. HILAIRE—ROUGEMONT 1951

Michel Method

Sampling Date	Number of Samples	Average Level	Standard Deviation
May 30—June 8 1	32	0.65	±0.08
June 12—June 18 2	6	0.61	±0.09
June 16—June 22 3	23	0.64	±0.11
July 25—July 27 4	27	0.79	±0.09
Oct. 3—Oct. 10 5	25	0.81	±0.09

Significance of Difference between 3 and 5—P = <0.01

Cholinesterase levels of Exposed Group

The five plasma levels for the exposed group are summarized in Table 9. Commencing with an average level of 0.78 at first sample, the level dropped to 0.74 at the end of the spraying period and rose to 0.85 in October, which agrees with the average plasma level of the control group. It must be observed that the group had had two 2-day sprayings during May, prior to the commencement of sampling. Additionally it may be emphasized that following each spraying there were around ten days during which exposure to parathion was reduced to the low residual levels existing in the orchards. In view of the work of Grob et al (26), it may possibly be accepted that recovery followed each exposure and this no doubt accounts for the fact that average levels are not more steeply reduced with each subsequent sampling. Some growers sprayed unexpectedly in July just prior to blood sampling so that this cannot be regarded as a fully unexposed period for the group.

Statistical analysis of the results revealed agreement between standard deviations of the exposed group and the controls, (Table 8). The difference between the third level, at the end of the spraying period and the fifth level, in October, had a significance probability of <0.016. Analysis of variance carried out on a reduced group for whom five values existed will be shown later in Table 16. The analysis confirmed significance of difference between periods to the degree of 5 percent.

Table 10, summarizes red cell values for the exposed group. Owing to an accident most of the second set of blood samples clotted and determination of cholinesterase could not be made. Comparison of level at third sampling—end of the exposed period—with the average level in October yielded a significance of difference equal to P value of <0.01. This period difference is strongly confirmed in analysis of variance of a group having five values for each subject as will be noted later in Table 18.

TABLE 11

PLASMA CHOLINESTERASE LEVELS FOR SPRAYERS REPORTING SYMPTOMS

ST. HILAIRE—ROUGEMONT 1951

Sampling Date	Number of Samples	Average Level	Standard Diveation
May 30—June 8 1	17	0.75	±0.15
June 12—June 18 2	13	0.75	±0.12
June 16—June 22 3	14	0.66	±0.13
July 25—July 27 4	12	0.69	±0.13
Oct. 3—Oct. 10 5	12	0.79	±0.18

Significance of Difference between 3 and 5—P = 0.04

An orchard power sprayer equipped with a concentrate conversion unit. Parathion spray is formed at nozzles and is carried to the trees by an air blast.
Spraying apple trees with parathion from turbine-type concentrate sprayer. (P. 21). Note protective clothing and respirator worn by operator.

TABLE 12

PLASMA CHOLINESTERASE LEVELS FOR SPRAYERS REPORTING NO SYMPTOMS

ST. HILAIRE—ROUGEMONT 1951

Sampling Date	Number of Samples	Average Level	Standard Deviation
May 30—June 8 1	16	0.81	±0.12
June 12—June 18 2	12	0.81	±0.16
June 16—June 22 3	13	0.82	±0.13
July 25—July 27 4	15	0.89	±0.19
Oct. 3—Oct. 10 5	12	0.91	±0.15

Periods, 1, 2, and 3 Combined are Significantly Different from 5 to P = 0.05.

TABLE 13

RED CELL CHOLINESTERASE LEVELS FOR SPRAYERS REPORTING SYMPTOMS

ST. HILAIRE—ROUGEMONT 1951

Sampling Date	Number of Samples	Average Level	Standard Deviation
May 30—June 8 1	16	0.67	±0.05
June 12—June 18 2	4	0.64	±0.11
June 16—June 22 3	10	0.60	±0.11
July 25—July 27 4	12	0.80	±0.06
Oct. 3—Oct. 10 5	12	0.82	±0.09

Period 3 Average Significantly Differently from 5 to P = <0.01

TABLE 14
RED CELL CHOLINESTERASE LEVELS FOR SPRAYERS REPORTING NO SYMPTOMS
ST. HILAIRE—ROUGEMONT 1951

Sampling Date	Number of Samples	Average Level	Standard Deviation
May 30—June 8 1	16	0.64	±0.10
June 12—June 18 2	2	0.57	±0.03
June 16—June 22 3	13	0.67	±0.11
July 25—July 27 4	15	0.78	±0.11
Oct. 3—Oct. 10 5	13	0.81	±0.10

Period 3 Significantly Different from Period 5 to P = <0.01

TABLE 15
PLASMA CHOLINESTERASE IN BLOOD OF SPRAYERS
ST. HILAIRE—ROUGEMONT 1951
Michel Method — Analysis by Student's t Test

	Averages 3rd Period	Standard Deviation	Averages in October	Standard Deviation	Percent Differences	Signif. of Differences
All Subjects 1	0.74	±0.15 η = 27	0.85	±0.17 η = 24	13	P 0.016
Reporting Symptoms 2	0.66	±0.13 η = 14	0.79	±0.18 η = 12	16	P <0.05
Reporting no 3 Symptoms	0.82	±0.13 η = 13	0.91	±0.15 η = 12	10	P ⊕ >0.05
Percent Difference 4 2 and 3	20	—	13	—	—	—
Significance of Difference 5	P 0.01	—	P >0.05	—	—	—

⊕ Av. all Values Exposed Period Significant from Oct. to P = 0.05

A Comparison of Blood Levels on the basis of Symptoms

In this study roughly half the exposed subjects reported no symptoms of ill-health. The remaining half reported headaches, nausea and other non-specific symptoms on one or more occasions with a few cases

TABLE 16
PLASMA CHOLINESTERASE IN BLOOD OF SPRAYERS
ST. HILAIRE—ROUGEMONT 1951
Michel Method — Analysis of Variance

Source of Variation	d. f.	Sum of Squares	m. s.	F.
SUBJECTS	19	14,788	778.3	5.04 **
Symptoms vs No Symptoms	1	8637	8637	25.28 **
Remainder	18	6151	341.7	2.21 **
Respirators vs No Respirators	1	1686	1686	2.32
Remainder	18	13,102	727.9	4.71 **
PERIODS	4	1738	434.5	2.81 *
First Three Periods	2	513	256.5	1.66
First Three vs Last	1	840	840	5.44 *
Remainder	1	386	386	2.51
RESIDUAL	76	11,731	154.4	
TOTAL		28,257		

* Significant at 5 Percent Significance Level
** Significant at 1 Percent Significance Level

TABLE 17
RED CELL CHOLINESTERASE IN BLOOD OF SPRAYERS
ST. HILAIRE—ROUGEMONT 1951
Michel Method — Analysis by Student's t Test

	Averages 3rd Period	Standard Deviation	Averages in October	Standard Deviation	Per cent Difference	Signif. of Difference
All Subjects 1	0.64	±0.11 η = 23	0.81	±0.09 η = 25	21	P <0.01
Reporting 2 Symptoms	0.60	±0.11 η = 10	0.82	±0.09 η = 12	27	P <0.01
Reporting no 3 Symptoms	0.67	±0.11 η = 13	0.81	±0.10 η = 13	17	P <0.01
Percent Difference 4 2 and 3	10	—	—	—	—	—
Significance of 5 Difference	P >0.05	—	P >0.05	—	—	—

of confining illness of short duration. Comment on diagnosis must perforce be guarded for the subjective nature of early symptoms associated with parathion intoxication makes clinical appraisal difficult. Nevertheless when adequate data on cholinesterase levels is available the position in diagnosis is strengthened and

TABLE 18
RED CELL CHOLINESTERASE IN BLOOD OF SPRAYERS
ST. HILAIRE—ROUGEMONT 1951
Michel Method — Analysis of Variance

Source of Variation	d. f.	Sum of Squares	m.s.	F
SUBJECTS	17	3277	192.8	3.06**
Sympyoms vs No Symptoms	1	13	13	0.06
Remainder	16	3264	204	3.23**
Respirators vs No Respirators	1		7	0.03
Remainder	16	3270	204.4	3.24**
PERIODS	3	4355	1451.7	23.01**
First and Third Periods	1	10	10	0.16
First and Third vs October	1	3828	3828	60.67**
Remainder	1	517	517	8.19**
RESIDUAL	51	3218	63.10	
TOTAL	71	10,850		

* Significant at 5 Percent Significance Level
** Significant at 1 Percent Significance Level

in our experiments the extensive blood findings warranted if not individually treatment at least group division and statistical validation of the data on the basis of symptoms.

Table 11 shows plasma values for those reporting symptoms. Attention is taken with the low value reached at the third period. The value of 0.69 obtained in July may be attributed to the fact that certain members of the group unexpectedly carried out a parathion spraying about three days before blood was sampled. The difference between periods 3 and 5 was significant to the level of $P = 0.04$.

Table 12 covers plasma levels for the group reporting no symptoms. Analysis by Student's t test proved that average level for all values during the exposed period was significant to $P = 0.05$ from the October level. As will be subsequently shown by analysis of variance there is a significant difference in level between those reporting symptoms and reporting no symptoms.

Matching red cell findings for the group reporting symptoms are shown in Table 13. Period differences are significant to $P = < 0.01$. Table 14 for those report-

TABLE 19
CHOLINESTERASE LEVELS OF SCIENTIST•
ST. HILAIRE—ROUGEMONT 1951
Michel Method

DATE	PLASMA	RED CELL
May 30—June 8	0.55	0.59
June 12—June 18	0.56	0.72
June 16—June 22	0.38	0.66
July 25—July 27	0.76	0.78
Oct. 3—Oct. 10	0.79	0.96

• First Exposed 5/19/51——I11 6/18/51.

ing no symptoms agrees closely with the symptoms group levels suggesting that red cell cholinesterase level has no clear cut association with the symptoms reported by these subjects.

Summary of Blood Work

Plasma data is summarized in Table 15 with analysis by Student's t test. Additional to observations already made, it may be noted that lowering of cholinesterase between periods 3 and 5 ran to 16 percent for those reporting symptoms who, as a group, were 20 percent lower than those reporting no symptoms.

Table 16 summarizes analysis of variance on the smaller group of persons to whom all five plasma values were obtained. The findings confirm those made by Student's t test and in addition prove that no significant difference existed between the levels of those wearing and not wearing respirators. The effect can largely be attributed to poor maintenance.

Table 17 summarizes analysis of red cell data by Student's t test. Additional to observations already made, it may be noted that lowering of cholinesterase on exposure ran to 21 percent for all sprayers, 27 percent for those reporting symptoms and 17 percent for those reporting no symptoms, there being no significant difference between the symptom and no symptom group.

Table 18 showing analysis of variance of a reduced red cell group for whom five values per person were available confirms t test analysis and additionally establishes no significance from wearing of respirators. This effect again reflects poor maintenance. It does not challenge the obvious importance of eliminating a route of entry to the body as unguarded as the respiratory route.

It has been stressed that clinical examination of

these exposed persons, did not yield, in the absence of blood findings any positive diagnosis of parathion intoxication. However, study of the cholinesterase changes in certain subjects led to the conclusion that intoxication had occurred but it cannot be emphasized too strongly that the diagnostic value of the cholinesterase test is doubtful unless changes are of considerable magnitude, or unless statistically workable data on the individual is available. For this reason our presentation stresses group experience and deals only briefly with the individual case.

Table 19 portrays the cholinesterase levels of one of the authors of this paper who was forced to leave the field on June 18th owing to illness—general malaise. His plasma recovery was rapid but it will be noted that the July value for red cell cholinesterase has not reached the level subsequently attained in October. Whether it is agreed that this evidence establishes a case of parathion poisoning is possibly of less importance than to appreciate that continued exposure over six weeks with careful personal protection, has been followed a few months later by doubling of plasma cholinesterase and an increase of 45 percent in red cell level. This emphasizes the importance of most careful precautions and medical supervision for exposed personnel.

DISCUSSION OF THE FINDINGS

The environmental findings reported in this paper represent an extensive description, if not a statistical sample of the exposure created by hand type and mechanical rocker type sprayers which are predominant in Eastern Canada orchards. It has been found that spray practice is suited more to the need for pest control than to the suitability of the weather. Spraying down wind under low wind velocity is the preferred though not always the practical technique. Down wind spraying resulted in low operator exposure running to around two micrograms of parathion per litre when 15 percent wettable powder was employed in concentrations of 0.75-1.5 pounds per hundred gallons of water and dispersed at the rate of 300-400 gallons per acre; spraying into the wind led to air concentrations of as high as 15 micrograms per litre. Tank filling does not appear specially hazardous. Residual parathion in decimal quantities existed as a general environmental constituent throughout the spray period at St. Hilaire.

Comparable assessment by Bradley and associates (32) in California citrus groves led to the finding of considerably lower levels during spraying but matching residual levels even though 25 percent wettable powder and considerably greater discharge rates were used. It is our opinion that the difference in air levels resulted from differences in spraying equipment and weather conditions.

The blood studies reported in this paper have demonstrated that St. Hilaire growers, as a group, have October cholinesterase levels statistically similar to the levels of a control group in Ottawa. This October similarity extends to the smaller groups reporting symptoms and reporting no symptoms; it covers both plasma and red cell fractions. In these circumstances if the Ottawa group are true normals so must the exposed groups and their fractions also be in their final sampling period.

Associated with exposure to parathion, the following major blood findings have been established on the exposed group (a) Average plasma levels were 13 percent lower at the end of the spray period than in October—average red cell level was 21 percent lower. (b) Division on the basis of symptoms revealed that average plasma level for persons reporting symptoms was 16 percent lower at the end of the spray period than in October—average red cell level was 27 percent lower. Those reporting no symptoms averaged significantly higher during exposure so far as plasma was concerned. In view of the internal and external comparisons available for statistical treatment and from the significance levels reached, it would seem that chance commonly associated with low values at n, can hardly have played a major role in the findings. These changes are not of the large magnitude to which the field has become accustomed in discussing positively diagnosed parathion poisoning, nevertheless Williams and Griffiths (30) have recently reported parathion poisoning at red cell cholinesterase reductions of 30-40 percent below control and plasma reductions of 10 percent. It is possibly reasonable to claim on the basis of health experience and blood study that marginal intoxication has been experienced by our exposed group. In this case the findings offer some encouragement that vigorous safety programs at field level can eliminate some hazard in application of this important insecticide.

CONCLUSIONS

1. This is the first reported study in which parathion exposure and its effects on the cholinesterase level of growers have been evaluated. Lowering of cholinesterase associated with the level of exposure at St. Hilaire has been confirmed. These observations combined with the fatalities and serious illnesses to growers from parathion in other parts of the continent emphasize that evaluation of the human toxicity of a proposed insecticide should precede licencing when high mammalian toxicity has been found in the laboratory; and furthermore that such evaluations should be initiated at the field-testing stage when large quantities of material are being employed under supervised conditions. A conservative and cautious approach to the licencing of new compounds is clearly desirable.
2. The concentration of 15 percent parathion for wettable powder licenced in Canada has been found associated with marginal intoxication of a group of thirty-three growers in the St. Hilaire-Rougemont area. The hand and mechanical rocker-type sprayers have

been employed. It seems probable that higher concentrations, as licenced in the United States, could have been additively dangerous in the St. Hilaire situation.

3. There is a trend toward new types of equipment employing higher air velocities. This equipment requires spray mixtures of higher concentrations though total spray is lower in amount. In view of the findings of this report, increase in authorized percentage of parathion used in Canadian wettable powder formalutions should await experiments to determine the operator exposure with the new equipment.

4. Parathion dust and emulsions already licenced should be investigated to determine the degree of hazard created by these preparations under Canadian application procedures.

5. This study has demonstrated that agricultural workers can have occupational hazards comparable to hazards of industrial occupations; it suggests that the protection provided to the industrial worker by existing health and safety legislation could properly be extended now to the agricultural worker.

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